Chapter 8
WATER QUALITY AND TREATMENT

There are water quality standards that must be met for different types of uses. These standards are generally based on health or water use technology requirements; water frequently needs treatment in order to meet these standards. Technology can also be employed to augment and make the most of available water resources. Human activities, such as waste disposal or pollution spillage, have the potential of degrading ground and surface water quality.

WATER QUALITY STANDARDS

Drinking Water Standards

There are two types of drinking water standards, primary and secondary. Both of these standards are the maximum contaminant levels for public drinking water systems. Primary drinking water standards include contaminants which can pose health hazards when present in excess of the maximum contaminant level (MCL). Secondary drinking water standards, commonly referred to as aesthetic standards, are those parameters which may impart an objectionable appearance, odor or taste to water, but are not necessarily health hazards. Current Florida Department of Environmental Protection (FDEP) primary and secondary drinking water standards are presented in Appendix G.

The U.S. Environmental Protection Agency (USEPA) is developing a ground water rule that specifies the appropriate use of disinfection to assure public health protection. The ground water rule proposal is anticipated to be established by the end of the year 2000. More information on the ground water rule can be obtained from the USEPA; internet access is also available at the following site: http://www.epa.gov/OGWDW/standard/gwr.html.

Large surface water systems must comply with the Stage 1 Disinfectants and Disinfection By-products Rule (D/DBPR) by December 2001. Ground water systems and small surface water systems must comply by December 2003. The new total trihalomethanes MCL may have an impact on public water supplies in the LWC Planning Area. Most systems in the LWC Planning Area have been able to meet the current TTHM standard of 0.10 mg/L by modifying or optimizing operation of their treatment and/or disinfection processes. TTHM concentrations in some cases are close to the current MCL of 0.10 mg/L. Some utilities in the LWC Planning Area will have difficulty in meeting more stringent TTHM standards without some plant modification. TTHM MCL information is given in Appendix G.

The Interim Enhanced Surface Water Treatment Rule (IESWTR) (December, 1998) will strengthen protection against microbial contaminants, especially *Cryptosporidium* (Federal Register CFR 40, Parts 9, 141, and 142). The IESWTR applies to public water systems that use surface water or ground water under the direct influence of surface water (GWUDI) and serve at least 10,000 people. States must conduct surveys on smaller systems (USEPA, 1998). This rule will come into affect with the Stage I D/DBPR. This rule contains new standards for turbidity. For more information, internet access is available at the following site: http://www.epa.gov/OGWDW/mdbp/ieswtr.html.

Nonpotable Water Standards

Water for potable and nonpotable water uses have different treatability constraints. Nonpotable water sources include surface water, ground water, and reclaimed water. Unlike potable water, with very specific quality standards to protect human health, water quality limits for nonpotable uses are quite variable and are dictated by the intended use of the water. For example, high iron content is usually not a factor in water used for flood irrigation of food crops, but requires removal for irrigation of ornamentals, which if iron stained, are not marketable. Excessive iron must also be removed for use in micro irrigation systems which become clogged by iron precipitate.

Nonpotable water uses include agricultural, landscape, golf course, and recreational irrigation. This water may also be acceptable for some industrial and commercial uses. For a source to be considered for irrigation for a specific use, there must be sufficient quantities of that water at a quality that is compatible with the crop it is to irrigate. Agricultural irrigation uses require that the salinity of the water not be so high as to damage crops either by direct application or through salt buildup in the soil profile. In addition, constituents which can damage the irrigation system infrastructure or equipment must be absent or economically removable. Water used for landscape, golf course, or recreational irrigation uses often has additional aesthetic requirements regarding color and odor. Irrigation water quality requirements are summarized in Appendix G.

In addition to water quality considerations associated with the intended use of nonpotable water, reclaimed water is subject to wastewater treatment standards which ensure the safety of its use (see Appendix H). As with any irrigation water, reclaimed water may contain some constituents at concentrations that are not desirable. Problems that might be associated with reclaimed water are no different from those of other water supplies and are only of concern if they hinder the use of the water or require special management techniques to allow its use. A meaningful assessment of irrigation water quality, regardless of the source, should consider local factors such as the specific chemical properties, the irrigated crops, climate, and irrigation practices (WSTB, 1996).

GROUND WATER CONTAMINATION AND IMPACTS TO WATER SUPPLY

Ground Water Contamination Sources

The Surficial Aquifer System is easily contaminated by activities occurring at land's surface in the LWC Planning Area. Once a contaminant enters the aquifer, it may be difficult to remove. In many cases, leaks, spills or discharges of contaminants migrate over long periods of time, resulting in contamination of large areas of the aquifer. The preferred method of addressing the issue of water supply contamination, therefore, is to prevent contamination of the aquifer, and protect public water supply wells and wellfields from activities that present a possible contamination threat. Saltwater intrusion also presents a potential threat to aquifers in the LWC Planning Area.

Solid Waste Sites

Landfills and old dumps within the boundaries of the LWC Planning Area are listed and displayed in Appendix G, with an accompanying location map. In addition to landfills and dumps there are also sludge spreading sites; usually tracts of land, often open range or citrus, where domestic wastewater treatment plant (WWTP) sludge is spread and incorporated into the soil.

Many of the older landfills and dumps were used for years with little or no control over what materials were disposed of in them. Although most have not been active for some time, they may still be a potential threat to the ground water resource. Ground water monitoring began in the early 1980's for all the landfills listed in Appendix G. No contamination problems were noted in any of these sites. The active landfills in the LWC Planning Area are lined; any unlined cells at the same sites have been closed (Krumbholz, 1998).

Contaminants from landfills are called leachates. Leachates often contain high concentrations of nitrogen and ammonia compounds, iron, sodium, sulfate, total organic carbon (TOC), biological oxygen demand (BOD), and chemical oxygen demand (COD). Less common constituents, which may also be present, include metals such as lead or chromium, and volatile or synthetic organic compounds associated with industrial solvents, such as trichloroethylene, tetrachloroethylene, and benzene. The presence and concentration of these constituents in the ground water are dependent upon several factors that dictate the extent and character of the resulting ground water impacts, these factors include the following:

- Landfill size and age
- Types and quantities of wastes produced in the area
- Local hydrogeology
- Landfill design/landfilling techniques

An effective ground water monitoring program is crucial for accurate determination of ground water degradation. Improperly located monitoring wells can result in the oversight of a contaminant plume, or certain parameters may not be observed in the ground water for many years, depending upon soil adsorption capacities and ground water gradient.

Hazardous Waste Sites

The Florida Department of Environmental Protection (FDEP) Waste Management Division sponsors several programs which provide support for hazardous waste site cleanup. There are many potential hazardous waste sites in the LWC Planning Area. Many older gas stations and dry cleaning facilities require some cleanup. Not all the potential hazardous waste sites actually contain contamination. The potential hazardous waste sites include locations in the Early Detection Incentive (EDI) Program, the Petroleum Liability and Restoration Program (PLIRP), the Abandoned Tank Restoration Program (ATRP), the Petroleum Cleanup Participation Program (PCPP), Pre-approved Advanced Cleanup Program (PACP) and other programs. Locations and cleanup status can be obtained through the FDEP Waste Management Division.

Superfund Program Sites

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as "Superfund," authorizes the USEPA to identify and remediate uncontrolled or abandoned hazardous waste sites. The National Priorities List (NPL) targets sites considered to have a high health and environmental risk. There are no NPL sites in the LWC Planning Area. The U.S. Environmental Protection Agency has a web site with more information about the Superfund program sites at http://www.epa.gov/superfund/sites.

Petroleum Contaminant Sites

Sites are reported to the FDEP, if contamination was noticed in the soil, surface water, ground water or monitoring wells. For more information on the petroleum clean up program, please refer to Florida Department of Environmental Protection world wide web site at http://www.dep.state.fl.us/dwm/programs/pcp/default.html.

Septic Tanks

Septic systems are a common method of on-site waste disposal. There are approximately 81,000 septic tanks in the LWC Planning Area (estimated from data in Marella, 1994, 1998 and SFWMD, 1998). Septic tanks may threaten ground water resources used as drinking water sources.

Saltwater Intrusion

Saltwater intrusion along the coast of the LWC Planning Area has been advanced by canal excavation and aquifer development for public water supplies and agriculture. In some channels, salinity control structures have been installed to limit saltwater encroachment by maintaining freshwater heads on the inland side. The greatest threat from saltwater intrusion lies where ground water and surface water gradients are lowest. Saltwater intrusion has been most evident in the lower Tamiami aquifer in the Naples Coastal Ridge and Bonita Springs/North Naples areas, and also in the water table aquifer in the area of Marco Island's public water supply withdrawals.

The SFWMD maintains a saltwater intrusion database called SALT that collects information on chloride, specific conductance, and water levels from the District's monitoring network. The monitoring network consists of data supplied from monitoring wells by the public water supply utilities and the USGS. Selected data acquired from this network, the USGS, and the District's DBHYDRO database were used to construct maps of average chloride concentrations in monitor wells in the water table, lower Tamiami, and mid-Hawthorn aquifers. These maps are intended to serve as an aid in visualizing the distribution of known values, rather than as an absolute indicator of saltwater intrusion. Appendix G includes maps containing well locations and average chloride concentrations.

In addition to saltwater intrusion from coastal waters, overdevelopment of aquifers which overlie more saline aquifers increases the possibility of upconing and contamination from the poorer quality layers. This potential exists throughout the LWC Planning Area. Although upconing of saline water is not considered to be true seawater intrusion, it is a significant threat because of its potential to degrade potable water supplies.

Cross contamination of shallow aquifers has also occurred from many of the Floridan aquifer wells in the LWC Planning Area. Numerous artesian wells were drilled into the highly mineralized Floridan Aquifer System from the 1930s through the 1950s for agricultural water supply and oil exploration. Many of these wells were short-cased, meaning the casings extended to less than about 200 feet below land surface, which exposed the shallower zones to invasion by the more saline Floridan water. Additionally, steel casings may have corroded, allowing inter-aquifer exchange through the casings. Often, if a well was abandoned, it was either plugged improperly, or simply left open, free-flowing on the land surface, and recharging the surficial aquifer with saline water. The result is the existence of localized sites throughout the shallow aquifers containing anomalously high concentrations of dissolved minerals.

In 1981 the Florida Legislature passed the Water Quality Assurance Act which required the water management districts to plug abandoned FAS wells. Under this program, many known wells in the LWC Planning Area were plugged. The federal government is currently offering a well abandonment program through the Soil Conservation Service for wells on specific agricultural lands.

Another source of localized pockets of mineralized water is connate water, theorized to be ancient seawater remaining from periods of inundation, entrapped within the aquifer, and relatively unexposed to freshwater flushing.

The effects of seawater intrusion, upconing, aquifer cross contamination, and connate water can create a complex and somewhat unpredictable scenario of local ground water quality. Monitor wells provide a great deal of information where they exist, but there are limits as to how many wells can be installed and monitored. Where more detailed information is required, additional methods may be needed to monitor the saltwater interface. In 1993, the District participated in a cooperative study in Broward County which utilized a surface geophysical method for delineating saltwater intrusion.

Geophysical surveys can provide extremely useful information about the extent of saltwater intrusion at relatively low cost (Benson and Yuhr, 1993).

Impacts to Water Supply

The costs and difficulty of removing a contaminant by a drinking water treatment plant can be considerable, depending on the material to be removed. Many of the major contamination sources identified in the LWC Planning Area can generate contaminants that are not easily treated. For example, nitrate is generated by septic systems or by fertilizer application, benzene from leaking gasoline tanks, and volatile organic compounds from various hazardous waste contamination sites. Water quality treatment methods for potable and nonpotable uses are described in the remaining portions of this section.

WATER TREATMENT TECHNOLOGIES

Several water treatment technologies are currently employed by the regional water treatment facilities in the LWC Planning Area. Chlorination, lime softening and membrane processes warrant discussion. The United States Environmental Protection Agency (USEPA) and Florida Department of Environmental Protection regulate water treatment plants. Higher levels of treatment may be required to meet increasingly stringent drinking water quality standards. In addition, higher levels of treatment may be needed where lower quality raw water sources are pursued to meet future demand. This section provides an overview of several water treatment technologies and their associated costs.

Disinfection

Disinfection, the process by which pathogenic microorganisms are destroyed, provides essential public health protection. All potable water requires disinfection as part of the treatment process prior to distribution. Chlorination is the only method of disinfection used in the LWC Planning Area.

Chlorination

Community public water supplies are required to provide adequate disinfection of the finished/treated water and to provide a disinfectant residual in the water distribution system. Disinfectant may be added at several places in the treatment process, but adequate disinfectant residual and contact time must be provided prior to distribution to the consumer. Chlorine is a common disinfectant used in the United States. The use of free chlorine as a disinfectant often results in the formation of levels of Trihalomethanes (THMs) and other disinfectant by-products (DBP) when free chlorine combines with naturally occurring organic matter in the raw water source. In December of 1998, President Clinton announced more stringent regulations in the D/DBPR for TTHMs, and water borne pathogens. The rule also regulates for the first time, *Cryptosporidium.* This may require facilities that modify their treatment processes to comply with the standards for these groups of compounds. Add on treatment technologies that are effective at removing these compounds or preventing their formation include ozone disinfection, granular activated carbon (GAC), enhanced coagulation, membrane systems, and switching from chlorine to chlorine dioxide (Jack Hoffbuhr, American Water Works Association Memorandum [December, 1998] regarding the Interim Enhanced Surface Water Treatment Rule).

The only disinfectant used in the LWC Planning Area is chlorination or chlorine used with ammonia to form chloramine. The rate of disinfection depends on the concentration and form of available chlorine residual, contact time, pH, temperature, and other factors. Current disinfection practice is based on establishing an amount of chlorine residual during treatment and, then, maintaining an adequate residual to the customer's faucet. Chlorine is also effective at reducing color. Chlorination has widespread use in the United States.

Capital and construction costs of a chlorination system are 70 to 80 percent less than a comparable ozonation system, while the operating costs are 25 to 50 percent less. Capital, operation, and maintenance costs for chlorination are presented in **Table 32**.

Table 32. Chlorination Treatment Costs.

Facility Size (MGD)	Capital Cost (per gallon/day capacity)	Engineering Cost (per gallon/ day capacity)	Operations and Maintenance Cost (per 1,000 gallons)
1	$.0638	$.00954	$.0577
3	$.0276	$.00414	$.0264
5	$.0216	$.00324	$.0207
10	$.0141	$.00211	$.0151
20	$.0100	$.00151	$.0126

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Ozonation

The use of ozone reduces unwanted disinfection by-products. However, ozone does not leave a residual like chlorine and chloramine which are persistent and can be measured. Ozone is an unstable gas that is produced on-site. After it is generated, the ozone gas is transferred into the water being treated. Contact times required for disinfection by ozone are short (seconds to several minutes) when compared to the longer disinfection time required by chlorine. Ozone, however, does not produce trihalomethanes as does chlorine and it is also effective at reducing color. Ozonation has widespread use in Europe and Canada, and limited use in the United States (Montgomery, 1985).

Disadvantages of ozone disinfection include its inability to maintain a persistent residual and unknown health effects associated with ozonation by-products. None of these by-product compounds have been shown to have potential health significance but only limited information is available on this subject. Compared to chlorine, ozone appears to generate less mutagenic by-products. A mutagenic compound is one which has the ability to produce a change in the DNA of a cell. Ozone by-products appear to be generally more biodegradable than their precursors. As a result, water receiving ozone treatment may promote regrowth of bacteria in the distribution system. Capital, operation, and maintenance costs for ozonation are presented in **Table 33**.

Table 33. Ozonation Costs.

Facility Size (MGD)	Capital Cost (per gallon/day capacity)	Engineering Cost (per gallon/day capacity)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
1	$.1644	$.0251	$.0602	$.0157
3	$.1167	$.0176	$.0330	$.0157
5	$.0936	$.0138	$.0246	$.0013
10	$.0773	$.0113	$.0166	$.0105
20	$.0575	$.0088	$.0133	$.0105

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Aeration

Aeration is used by 5 of the 31 regional water treatment facilities in the LWC Planning Area. This treatment process is used in areas with high quality raw water which only needs to be aerated to remove hydrogen sulfide, which causes tastes and odors, or the removal of carbon dioxide, which can reduce the lime demand in lime softening treatment. Aeration also adds oxygen to the water. More recently, aeration has been used to remove trace volatile organic contaminants from water, which are believed to cause adverse health effects.

Aeration Process

In most water treatment aeration process applications, air is brought into contact with water in order to remove a substance from the water, a process referred to as desorption or stripping. This can be accomplished through packed towers, diffused aeration, or tray aerators.

A packed tower consists of a cylindrical shell containing packing material. The packing material is usually individual pieces randomly placed into the column. The shapes of the packing material vary and can be made of ceramic, stainless steel, or plastic. Water is introduced at the top of the tower and falls down through the tower as air is passing upward.

Diffused aeration consists of bringing air bubbles in contact with a volume of water. Air is compressed and then released at the bottom of the water volume through bubble diffusers. The diffusers distribute the air uniformly through the water cross section and produce the desired air bubble size. Diffused aeration has not found wide spread application in the water treatment field.

Cascading tray aerators depend on surface aeration that takes place as water passes over a series of trays arranged vertically. Water is introduced at the top of a series of trays. Aeration of the water takes place as the water cascades from one tray to the other.

Aeration Costs

The cost of aeration is relatively low. Costs decrease with facility size as shown in **Table 34**.

Table 34. Aeration Treatment Costs.

Facility Size (MGD)	Capital Cost (per gallon/day capacity)
1	$.0113
3	$.0083
5	$.0075
10	$.0053
20	$.0050

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Lime Softening

Lime softening is used at 18 of the 31 regional water treatment facilities in the LWC Planning Area. Lime softening treatment systems are designed primarily to soften hard water, reduce color and to provide the necessary treatment and disinfection to ensure the protection of public health.

Lime Softening Process

Lime softening refers to the addition of lime to raw water to reduce water hardness. When lime is added to raw water, a chemical reaction occurs that reduces water hardness by precipitating calcium carbonate and magnesium hydroxide. Disinfectant may be added at several places in the treatment process, but adequate disinfectant residual and contact time must be provided prior to distribution to the consumer. The lime softening process is effective at reducing hardness, but is relatively ineffective at controlling contaminants such as chloride, nitrate, TTHM precursors, and others (Hamann et al., 1990).

Lime softening is ineffective in removing the chloride ion and only fairly effective at reducing total dissolved solids (TDS). Chloride levels of raw water sources expected to serve lime softening facilities should be below the chloride MCL of 250 mg/L to avoid possible exceedences of the standard in the treated water. The current finished water TDS MCL is 500 mg/L. Concentrations above 500 mg/L in the treated water are acceptable so long as no other MCLs are exceeded.

Nitrate is not effectively removed by the lime softening process. Lime softening facilities with raw water sources with nitrate concentrations exceeding the MCL of 10 mg/L will probably require additional treatment to meet the standard.

Proposed Safe Drinking Water Act regulations for TTHMs and DBPs will require that many existing lime softening facilities modify their treatment processes to comply with the standards for these groups of compounds. Add-on treatment technologies that are effective at removing these compounds or preventing their formation include ozone disinfection, granular activated carbon (GAC), and air stripping.

Lime Softening Treatment Costs

Capital construction costs for lime softening treatment facilities tend to be similar to those of other treatment processes (**Table 35**). The cost advantages of lime softening are in operating and maintenance expenses, where costs are typically 20 percent less than for comparable membrane technologies. However, an increase in total hardness of the raw water source will require increased amounts of lime to maintain the same water quality. In addition, any free carbon dioxide present in the raw water must first be satisfied by the lime before any significant softening can occur, which will impact the costs associated with this treatment process.

Membrane Processes

Membrane technology has continued to improve in anticipation of the more stringent water quality regulations that the USEPA announced in December 1998. Membrane processes can remove dissolved salts, organic materials that react with chlorine DBP precursors as well as provide softening. Several membrane technologies are used to treat drinking water: reverse osmosis (RO), nanofiltration, ultrafiltration, and microfiltration. Each membrane process has a different ability in processing drinking water.

Table 35. Lime Softening Treatment Costs.

Facility Size (MGD)	Capital Cost (per gallon/ day capacity)	Engineering Cost (per gallon/ day capacity)	Land Requirements (Acres)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
3	$1.63	$.25	1.5	$.60	$.023
5	$1.57	$.24	2.5	$.56	$.023
10	$1.53	$.23	4.0	$.50	$.021
15	$1.26	$.19	6.0	$.41	$.020
20	$1.13	$.16	8.0	$.38	$.020

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Reverse Osmosis

Reverse Osmosis (RO) technology has been used in Florida for a number of years. Major public water supply RO facilities include Cape Coral, Collier County, Greater Pine Island, Marco Island, and Island Water Association (Sanibel) in the LWC Planning Area.

Reverse Osmosis Process

RO is a pressure driven process that relies on forcing water molecules (feed water) through a semipermeable membrane to produce fresh water (product water). Dissolved salts and other molecules unable to pass through the membrane remain behind (concentrate or reject water). RO is capable of treating feed waters of up to 45,000 mg/L TDS. Most RO applications involve brackish feed waters ranging from about 1,000 to 10,000 mg/L TDS. Transmembrane operating pressures vary considerably depending on TDS concentration (**Table 36**). In addition to treating a wide range of salinities, RO is effective at rejecting naturally occurring and synthetic organic compounds, metals, and microbiological contaminants. The molecular weight cutoff (MWC) determines the level of rejection of a membrane.

Advantages of RO treatment systems include their ability to reject organic compounds associated with formation of TTHMs and other DBPs, small space requirements, modular type construction and easy expansion. Disadvantages of RO systems include high capital cost, requirements for pretreatment and post-treatment systems, high corrosivity of the product water, and disposal of the reject. RO is also less efficient than lime softening, so more raw water is needed to produce finished water.

Disposal of RO reject is regulated by the FDEP. Various disposal options include surface water discharge, deep well injection, land application and reuse. Whether a disposal alternative is permittable depends on the characteristics of the reject water and

Table 36. Reverse Osmosis Operating Pressure Ranges.

System	Transmembrane Pressure Operating Range (psi)	Feed Water TDS Range (mg/L)	Recovery Rates (%)
Ocean water	800-1,500	10,000-50,000	15-55
Standard pressure	400-650	3,500-10,000	50-85
Low pressure	200-300	500-3,500	50-85
Nanofiltration	45-150	Up to 500	75-90

Source: AWWA, 1990, Water Quality and Treatment.

disposal site (letter dated December 12, 1990 from B.D. DeGrove, Point Source Evaluation Section, FDEP, Tallahassee, FL).

Reverse Osmosis Costs

RO treatment and associated concentrate disposal costs for a typical South Florida system, (2,000 mg/L TDS, 400 PSI) are provided in **Tables 37** and **38**. Variables unique to RO capital costs include system operating pressures and concentrate disposal, while variables unique to RO operations and maintenance costs include electrical power, chemical costs, membrane cleaning and replacement, and concentrate disposal.

Table 37. Reverse Osmosis Treatment Costs.

Facility Size (MGD)	Capital Costs (per gallon/ day capacity)	Engineering Cost (per gallon/ day capacity)	Land Requirements (Acres)	Operations and Maintenance Cost (per 1,000 gallons)	Energy Cost (per 1,000 gallons)
3	$1.76	$.26	.40	$.58	$.29
5	$1.59	$.24	.40	$.54	$.29
10	$1.47	$.23	.50	$.51	$.29
15	$1.43	$.21	.63	$.50	$.29
20	$1.40	$.20	.78	$.38	$.29

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Methods of determining capital and operations and maintenance costs vary from utility to utility, and as a result, cost comparisons of treatment processes can be difficult (Dykes and Conlin, 1989). Site specific costs can vary significantly as a result of source

Table 38. Concentrate Disposal Costs.

Deep Well Disposal Facility (MGD)	Capital Cost (per gallon/ day capacity)	Engineering Cost (per gallon/ day capacity)	Land Requirements (Acres)	Operations and Maintenance Cost (per 1,000 gallons)
3	$.73	$.109	0.5	$.040
5	$.55	$.083	0.5	$.030
10	$.50	$.075	1.0	$.028
15	$.46	$.070	2.0	$.025
20	$.38	$.056	3.0	$.020

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

water quality, reject disposal requirements, land costs, use of existing water treatment plant infrastructure, etc. Detailed cost analyses are necessary when considering construction of RO water treatment facilities. As a general rule, however, RO costs are 10 to 50 percent higher than lime softening.

The recent improvements in low pressure membranes has reduced the electrical costs associated with reverse osmosis systems. Because reverse osmosis pump power consumption is directly proportional to pressure, the low pressure systems can provide significant reductions in power consumption. The reverse osmosis treatment costs presented herein do not reflect the recent improvements in membrane technology.

Membrane Softening

Membrane softening or nanofiltration is an emerging technology that is currently in use in Florida. Membrane softening differs from standard reverse osmosis systems in that the membrane has a higher MWC, lower operating pressures and feed water requirements of 500 mg/L or less of TDS. One significant advantage of the membrane softening technology is its effectiveness at removing organics that function as TTHM and other DBP precursors. Given the direction of increasing federal and state regulation of drinking water quality, membrane softening seems to be a viable treatment option towards meeting future standards. A number of membrane softening facilities have been installed in the LWC Planning Area, including the city of Fort Myers, Collier County, and Gulf Corkscrew.

The costs associated with membrane softening are similar to those of reverse osmosis, with operations and maintenance expenses tending to be lower. Membrane softening treatment costs are shown in **Table 39**.

Table 39. Membrane Softening Costs.

Facility Size (MGD)	Capital Costs (per gallon/day capacity)	Engineering Cost (per gallon/ day capacity)	Land Requirements (Acres)	Energy Cost (per 1,000 gallons)	Operations and Maintenance Cost (per 1,000 gallons)
3	$1.67	$.25	0.40	$.200	$.55
5	$1.52	$.23	0.40	$.200	$.53
10	$1.41	$.21	0.50	$.200	$.50
15	$1.38	$.21	0.63	$.200	$.48
20	$1.33	$.20	0.78	$.200	$.46

Source: PBS&J, 1991 Water Supply Cost Estimates converted to 1999 dollars.

Ultrafiltration

Ultrafiltration is a pressure driven processes that removes nonionic matter, higher molecular weight substances and fractions colloids. Colloids are extremely fine sized suspended materials that will not settle out of the water column.

Microfiltration

Microfiltration is also a pressure driven process but it removes coarser materials than ultrafiltration. Although this membrane type removes micrometer and submicrometer particles it allows dissolved substances to pass through.

Electrodialysis and Electrodialysis Reversal

Electrodialysis (ED) is an electrochemical process that involves the movement of ions through anion- and cation-selective membranes from a less concentrated solution to a more concentrated solution by the application of direct electrical current. Electrodialysis reversal (EDR) is a similar process but provides for the reversing of the electrical current which causes a reversing in the direction of ion movement. ED and EDR are useful in desalting brackish water with TDS feedwater concentrations of up to 10,000 mg/L. However, ED/EDR is generally not considered to be an efficient and cost effective organic removal process and therefore is usually not considered for TTHM precursor removal applications (AWWA, 1988). Available cost data for ED/EDR is limited, but for the same area appear to be 5 to 10 percent higher than reverse osmosis treatment (Boyle Engineering, 1989).

Distillation

The distillation treatment process is based on evaporation. Saltwater is boiled and the dissolved salts, which are nonvolatile, remain behind. The water vapor is cooled and condenses into fresh water. Two distinct treatment processes are in use: multistage flash (MSF) distillation and multiple effect distillation. Capital construction costs and operation and maintenance expenses are three to five times as expensive as brackish water reverse osmosis systems and/or EDR (Buros, 1989).

WATER TREATMENT FACILITIES

Potable Water Treatment Facilities

Potable water in the LWC Planning Area is supplied by three main types of facilities: (a) regional public water supply treatment facilities, municipal or privately owned; (b) small developer/home owner association or utility owned public water supply treatment facilities; (c) self-supplied individual wells that serve individual residences. Many of the smaller facilities are constructed as interim facilities until regional potable water becomes available. At that time, the smaller water treatment facility is abandoned upon connection to the regional water system.

The Florida Department of Environmental Protection (FDEP) regulates regional public water supply systems in the LWC Planning Area. The local health department is required to regulate the smaller facilities, as described; (1) those water systems that have less than 15 service connections; or (2) facilities which regularly serve less than 25 individuals daily at least 60 days out of the year; or (3) facilities which serve at least 25 individuals daily less than 60 days out of the year (Chapter 62-550, F.A.C.). The LWC Plan reports on the FDEP regulated facilities with a permitted average daily flow of 0.5 million gallons per day (MGD) or greater.

There are 31 regional water treatment facilities within the LWC Planning Area. These facilities primarily use raw ground water, and most are considering ground water sources to meet future demands. Fort Myers and Lee County use surface water from the Caloosahatchee River, while Clewiston uses surface water from Lake Okeechobee. Wellfield and surface water withdrawal locations for these facilities are shown in **Figures 15 - 17**.

Other detailed information provided in Appendix D include the source, aquifer or surface water name and pump capacity for each of the wells or surface pumps; existing, proposed, and future sources of raw water; and water treatment methods for each facility. The existing treatment technologies employed by the facilities are chlorination, reverse osmosis, aeration, and lime or membrane softening.

Figure 15.
Removed for Security Purposes

Figure 16.
Removed for Security Purposes

Figure 17.
Removed for Security Purposes

Wastewater Treatment Facilities

Wastewater treatment in the LWC Planning Area is provided by (a) regional wastewater treatment facilities, municipal or privately owned; (b) small developer/home owner association or utility owned wastewater treatment facilities; and (c) septic tanks.

Many of the smaller facilities are constructed on an interim basis until regional wastewater facilities become available, at which time the smaller wastewater treatment facility is abandoned upon connection to the regional wastewater system. The regional wastewater service areas are shown in **Figure 18**. Wastewater treatment in the LWC Planning Area is regulated by the FDEP for all facilities. The following wastewater treatment facilities are exempt from FDEP regulation and are regulated by the local health department for each county: (1) those with a design capacity of 2,000 GPD or less which serve the complete wastewater and disposal needs of a single establishment; or (2) septic tank drain field systems and other on-site sewage systems with subsurface disposal and a design capacity of 10,000 GPD or less, which serve the complete wastewater disposal needs of a single establishment (Chapter 62-600, F.A.C.). The LWC Water Supply Plan

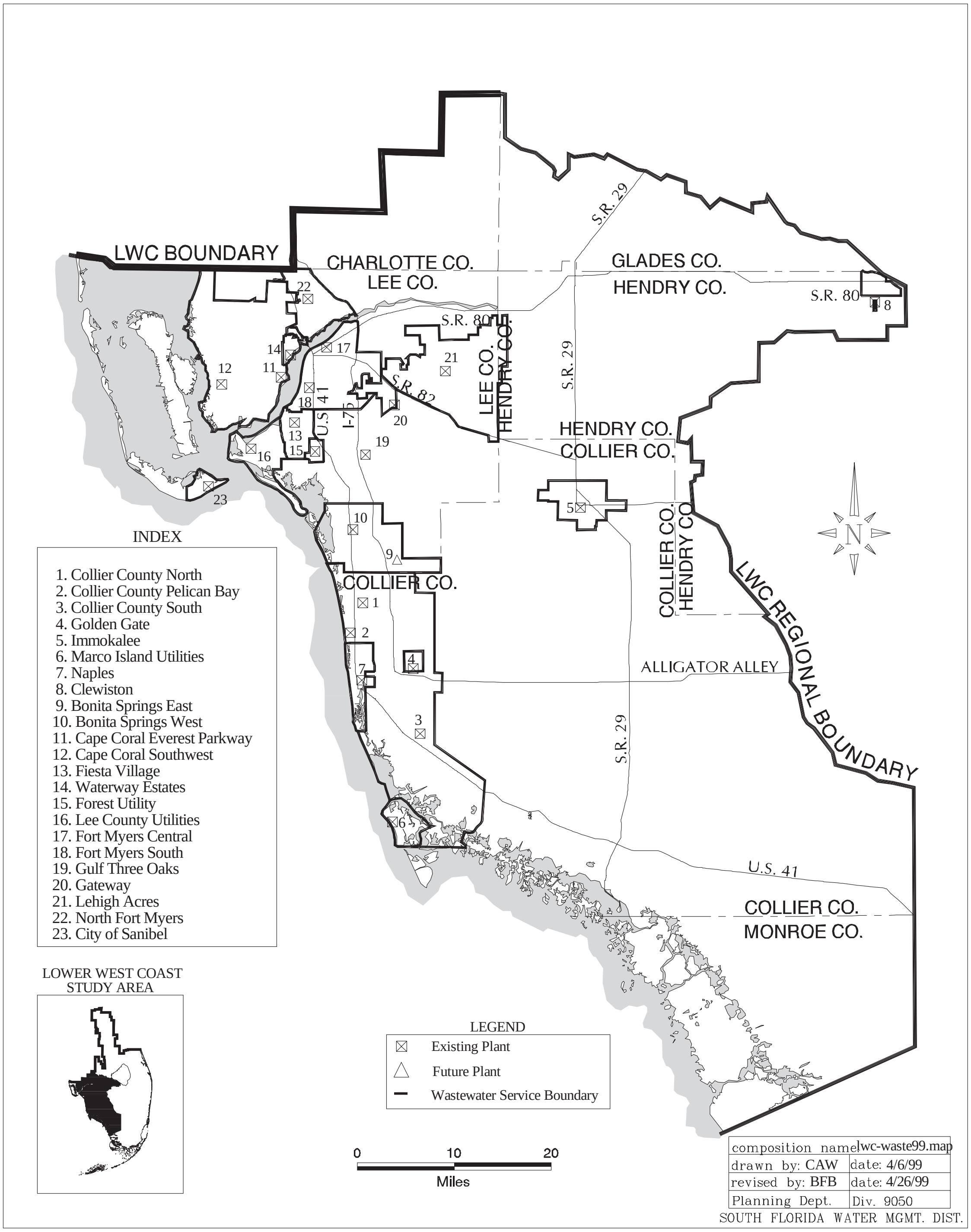

Figure 18. Regional Wastewater Treatment Facility Locations.

reports on the FDEP regulated facilities with a permitted average daily flow of 0.5 million gallons per day (MGD) or greater.

All the FDEP regulated facilities use the activated sludge treatment process. The methods of reclaimed water/effluent disposal include surface water discharge, reuse, and deep well injection. Six facilities are permitted to use surface water discharge and six facilities use deep well injection systems.

There are 22 existing regional wastewater treatment facilities in the LWC Planning Area with a FDEP permitted capacity equal to or greater than 0.50 MGD. These facilities treated an average of 58 MGD in 1997. Nineteen of the facilities used reuse for all or a portion of their disposal needs in 1997 resulting in 37 MGD being reused. Reuse included irrigation of residential lots, medians, green space and golf courses and ground water recharge via percolation ponds. In addition to reuse, 5 MGD was disposed of by deep well and 16 MGD was disposed of by surface water discharge. The volume of treated wastewater is projected to increase to 97 MGD by 2020.

Specific information on each of the wastewater treatment facilities is provided in Appendix D. The information includes summaries of the existing, proposed, and future wastewater treatment and disposal methods. Capacity and reuse feasibility for each facility, as well as known future plans are also discussed.